THE WEATHER AND CIRCULATION OF MAY 1953[1]—

One of the Worst Tornado Months on Record

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SEVERE LOCAL STORMS

In many sections of the United States the weather of May 1953 was notable for severe thunderstorm activity and accompanying phenomena: torrential rainfall, local floods, huge hailstones, destructive winds, and devastating tornadoes. Most spectacular were the destructive tornadoes which occurred mainly across the South from Texas to Alabama, in the Plains States, and along the northern border from Montana to the Great Lakes region (fig. 1). Tornadoes normally are most frequent in May in the United States, but the total number of tornadoes reported during May 1953 was 113, the greatest number for any month of the entire period of record commencing in 1916 [1]. It must be pointed out though that strict comparison with tornado counts for earlier years may not be justified since in recent years increased population distribution and more extensive tornado reporting have probably resulted in an increase in the proportion of

[1] See Charts I–XV following p. 154 for analyzed climatological data for the month.

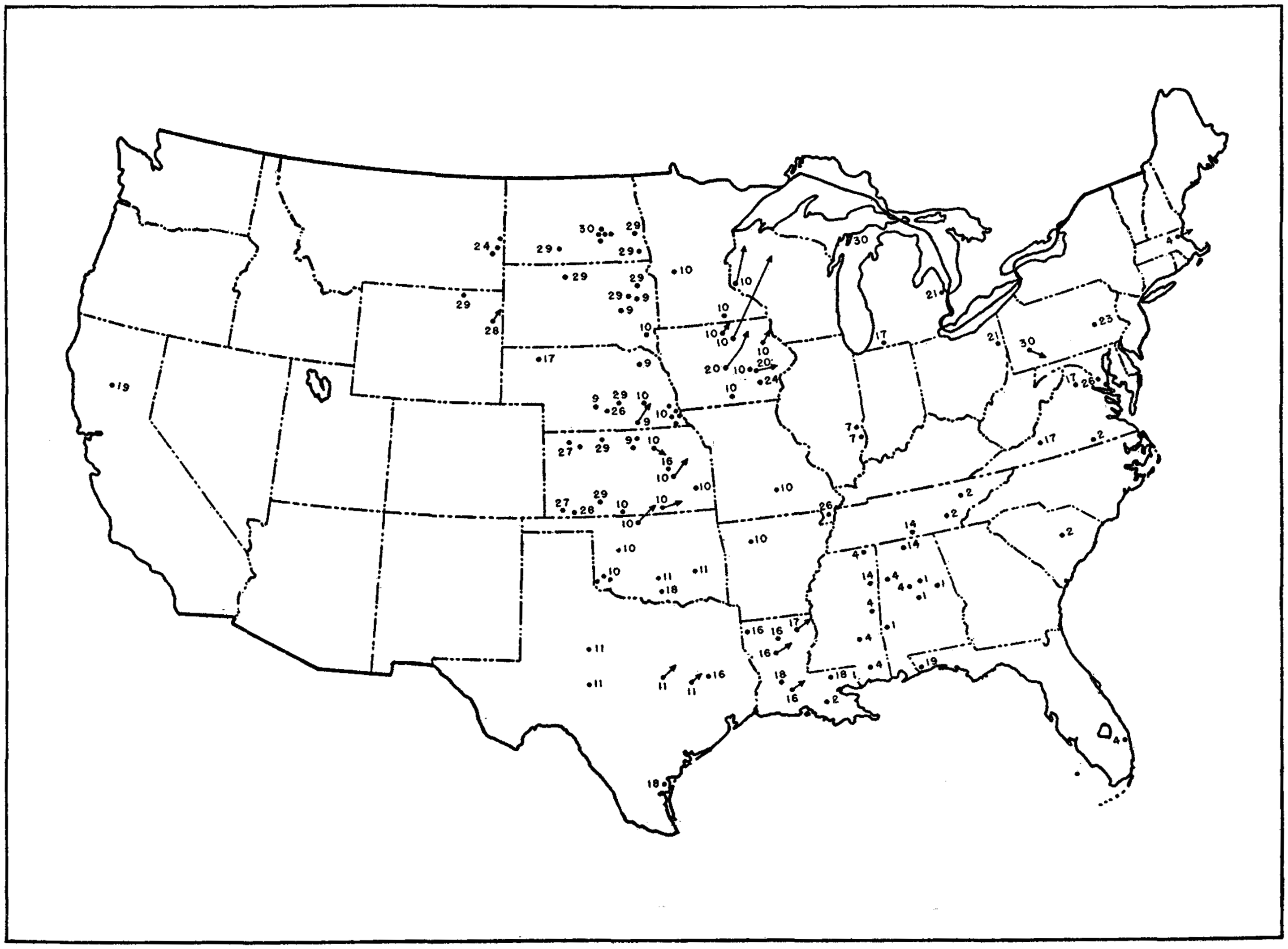


FIGURE 1.—Location of tornadoes reported over the United States during May 1953. Numbers indicate date of occurrence and arrows indicate well-marked tracks. Note the concentrations in the South Central States and northward through the Plains. Twenty-seven of the total of 113 tornadoes shown occurred on May 10. Figure is based on information provided by Climatological Information Section of Weather Bureau. These reports are not complete and it is probable that additional tornadoes occurred.

tornadoes reported. An alternate way of measuring frequency of tornadic activity is in terms of the number of days with tornadoes in the United States as a whole. For May 1953 there were 21 tornado days, a figure exceeded only by May 1933 with 23 and May 1950 with 22, and equalled in May 1951. Thus, it must be concluded that this May was one of the worst tornado months on record. On May 10 alone some 27 tornadoes were reported over the region from Oklahoma and Arkansas northward into Minnesota and Wisconsin (fig. 1). These occurred to the east and southeast of a deep cyclone which moved northward from western Kansas to eastern North Dakota (Chart X). Associated with this Low was a deep trough aloft and an intense cold front oriented North-South along which cold, dry Pacific polar air was displacing a broad southerly current of very moist maritime tropical air. On May 11, as this same cold front became stationary over central Texas, additional tornadoes developed in Texas and Oklahoma. Two of these ripped through the cities of San Angelo and Waco, Tex. The tornado in Waco resulted in 114 deaths and caused property damage estimated at about 14 million dollars—the heaviest financial setback to a city in tornado history.

Heavy rainfall for several days in central and western Louisiana and eastern Texas caused major floods in the

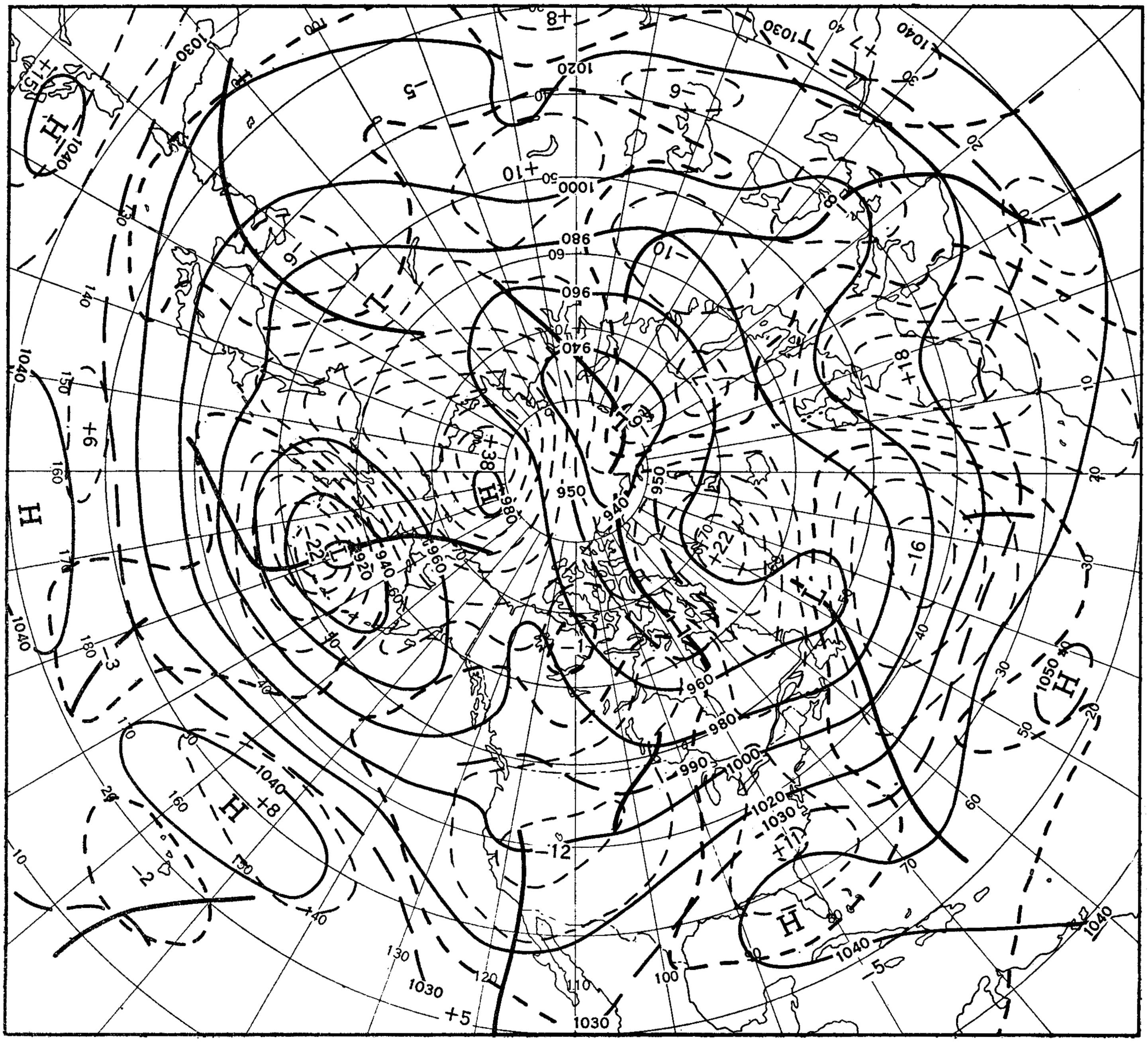


FIGURE 2.—Mean 700-mb. height contours and departures from normal (both labeled in tens of feet) for May 2–31, 1953. Basic wave pattern over United States consisted of trough in West and ridge in East with anomalous southerly flow components over middle of country. This is recognized pattern associated with severe local storminess in spring over large portions of United States.

second half of the month. Some of the rivers in this area reached their highest flood stages in 40 years. Near the end of the month heavy rains in Montana and the Northern Plains caused local flooding of rivers resulting in considerable property damage. Damaging hailstorms were in the news in May, too. On May 6, 7, and 9 hail occurred in sections of the central Atlantic Coast. Near the end of the month hailstones as big as baseballs fell in such cities as Washington and Detroit, shattering windows and denting many automobiles.

RELATED MONTHLY MEAN CIRCULATION FEATURES

The large-scale features of the 700-mb. monthly mean circulation pattern over the North American region for May provide much of the explanation for this widespread severe storminess. Figure 2 shows that the circulation over the United States was dominated by a trough in the West and a ridge in the East, both of which had height departures from normal of about equal magnitude (−12 over Nevada, +11 over South Carolina). This circulation pattern provided a stronger-than-normal flow of air from the Gulf of Mexico northward through the central part of the country, and also an abnormally strong eastward flux of cool Pacific air through the Southwest trough into the region east of the Rockies. This Pacific air remained cold and unstable in mid-troposphere in its travel across the West because of the prevailing cyclonic circulation. It is believed that a large-scale circulation pattern of this type is especially favorable for the development of severe squall lines and tornadic activity since it provides for more frequent and more intense interactions between the maritime polar and maritime tropical air masses than would normally occur. It has long been recognized, of course, that intense squall lines and tornadoes are most favored synoptically where cold, dry Pacific air masses are advected rapidly aloft over moist tropical air in lower levels (see [2]). It may be recalled that an unusually large number of tornadoes also occurred during April 1953. Although the circulation patterns in April and May were different in many respects, they were alike in that the flow of Pacific air masses into the central United States was stronger and more cyclonic than normal [3].

Even though severe storminess was frequent during May, many States with a considerable number of tornadoes did not have abnormally heavy precipitation for the month as a whole (Chart III). In fact, in most of Texas, Oklahoma, Kansas, Nebraska and Iowa, where more tornadoes than normal were observed (fig. 1), precipitation amounts generally totaled well below normal. This may, of course, be associated with the fact that tornadoes occurred only during five or six days of the month in these States. However, even on those days when several tornadoes were reported in the Plains States, 24-hour precipitation amounts rarely exceeded ½ inch. It is probable that the cause of these relatively small precipitation amounts accompanying severe storminess in the Plains lies in the considerable amount of dry Pacific air aloft and prevailing downslope motion east of the Rockies associated with circulation regimes of the type shown in figure 2.

The difference in the monthly precipitation regimes over the Southwest and Northwest is quite interesting and rather typical. It may be seen from figure 2 and Chart III that heavier-than-normal precipitation generally occurred where flow was more easterly than normal to the north of the negative height anomaly center over Nevada, and lighter-than-normal rainfall occurred to the south under fast westerly flow. The physical explanation for this relationship apparently lies in the tendency for more frequent than normal occurrence during the month of upper closed Lows near the negative height anomaly center and in the typical upward motion to the north of such systems.

TRANSITION OF CIRCULATION AND PRECIPITATION REGIMES DURING MAY

Of fundamental importance in understanding the weather of May 1953 was the gradual but considerable change in large-scale circulation pattern which took place over the North American region during the month. To illustrate these transitions and their effect on precipitation three consecutive 10-day mean 700-mb. charts and the corresponding 10-day percentage of normal precipitation are presented in figures 3 and 4 respectively. In addition, to provide further insight into these precipitation patterns, counts have been made for each 10-day period of the number of days with surface fronts (of any type) located within equal-area squares (fig. 5).

In the first third of May four troughs existed at middle and lower latitudes between the west-central Pacific and the central Atlantic (fig. 3A). Over the United States two ridges, one near each coast, flanked the major trough extending from the Northern Plains southward and southwestward to Lower California. Neither the eastern ridge nor the United States trough extended very much north of the Canadian border since a broad northwesterly flow existed over eastern Canada, and the deep cyclonic vortex centered over Baffin Island was essentially connected with the central Atlantic trough. The eastern United States ridge was of rather small amplitude from Pennsylvania southward while over the Great Lakes it had a more pronounced anticyclonic development.

Precipitation over the country in these first ten days of May was well related to these circulation features (fig. 4A). A large area from east Texas northeastward to New England and eastward to the Carolinas was covered for the most part with greater than normal amounts of rainfall. This area was located under southwesterly flow aloft which transported abundant supplies of moist tropical air northward from the Gulf of Mexico. Instrumental in the precipitation of much moisture from these air masses were the southerly components of flow, usually an indicator of upward motion, and the frontal systems in the South and East. Note how the region in which

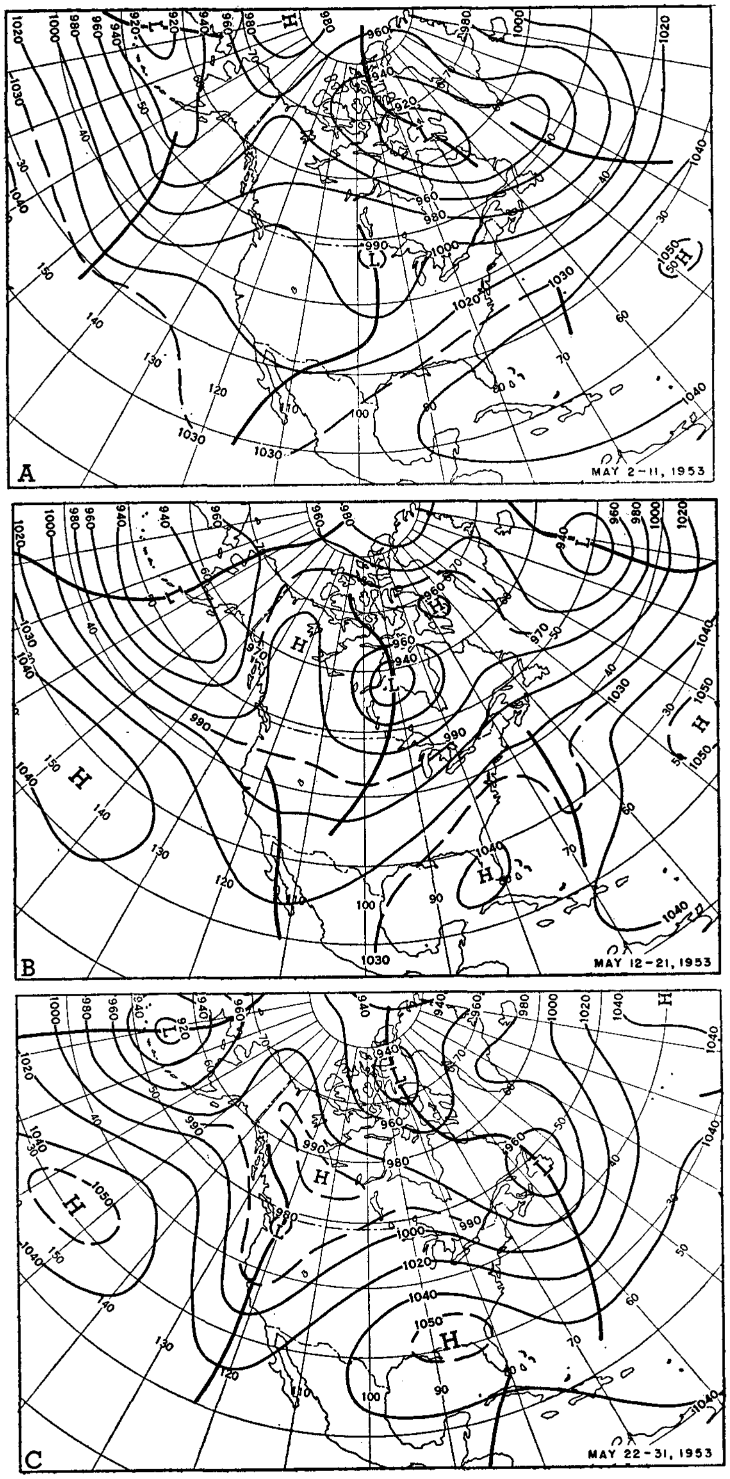


Figure 3.—Mean 700-mb. charts for (A) May 2-11, 1953, (B) May 12-21, 1953, and (C) May 22-31, 1953 (contours labeled in tens of feet). Note nearly complete reversal of wave pattern over United States from first to third decade of month with a large ridge replacing a trough over middle of country and a deep trough replacing a ridge near West Coast.

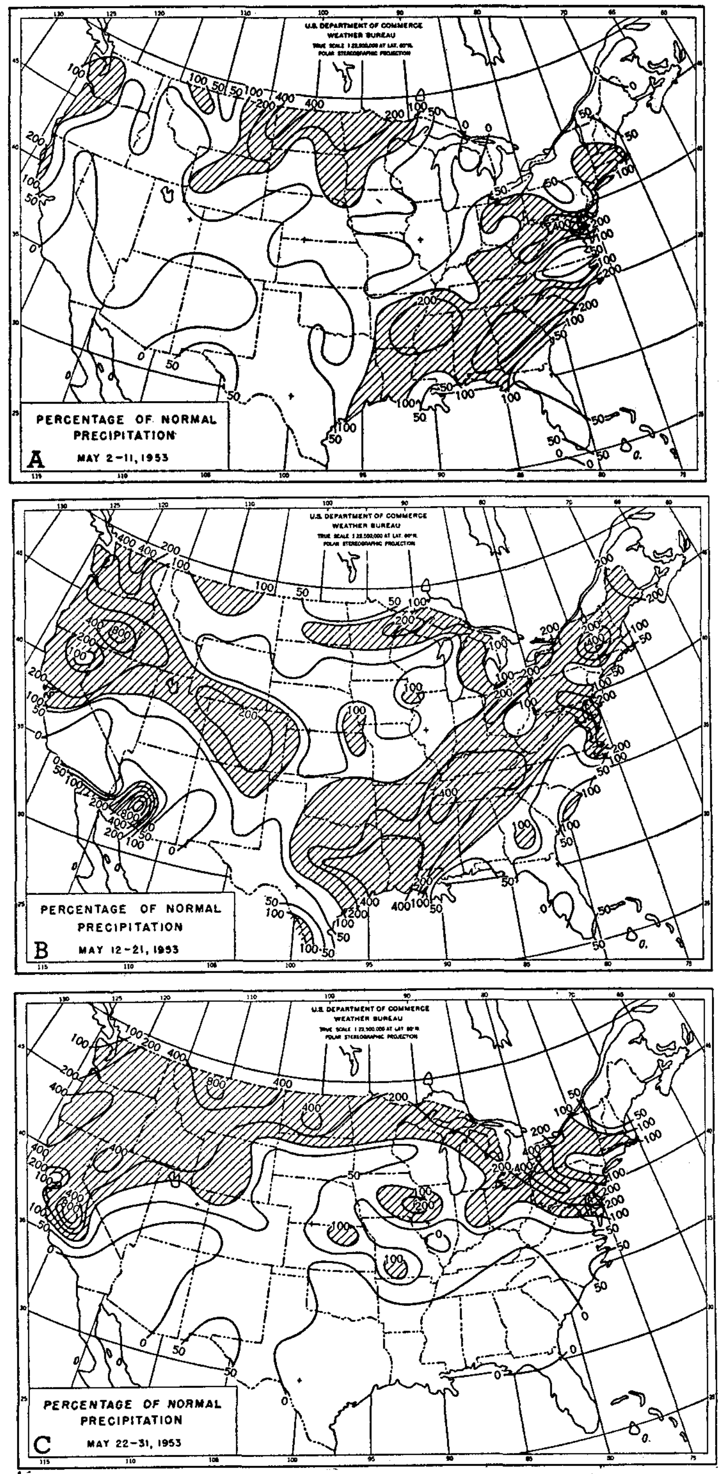


Figure 4.—Percentage of normal precipitation amounts for the periods (A) May 2-11 1953, (B) May 12-21, 1953, and (C) May 22-31, 1953. Regions in excess of normal are shaded. Heavy rainfall in South in first two-thirds of month was followed by complete absence of rainfall in same area during last 10 days of month. This was related to large-scale circulation changes illustrated in figure 3.

fronts were present during six or more days of the period (fig. 5A) extended eastward and northeastward from east Texas in fairly close correspondence with the area of supernormal precipitation. Over much of the Great Lakes region and parts of the Midwest precipitation was abnormally light. It is believed that the nearly separate anticyclonic circulation aloft over the Lakes provided so much subsidence that little rain fell even though there were fronts present on six or more days over the region. Over the Plains heavier-than-normal precipitation occurred mainly near the Canadian border from Montana eastward to Minnesota. This is attributable to the closed

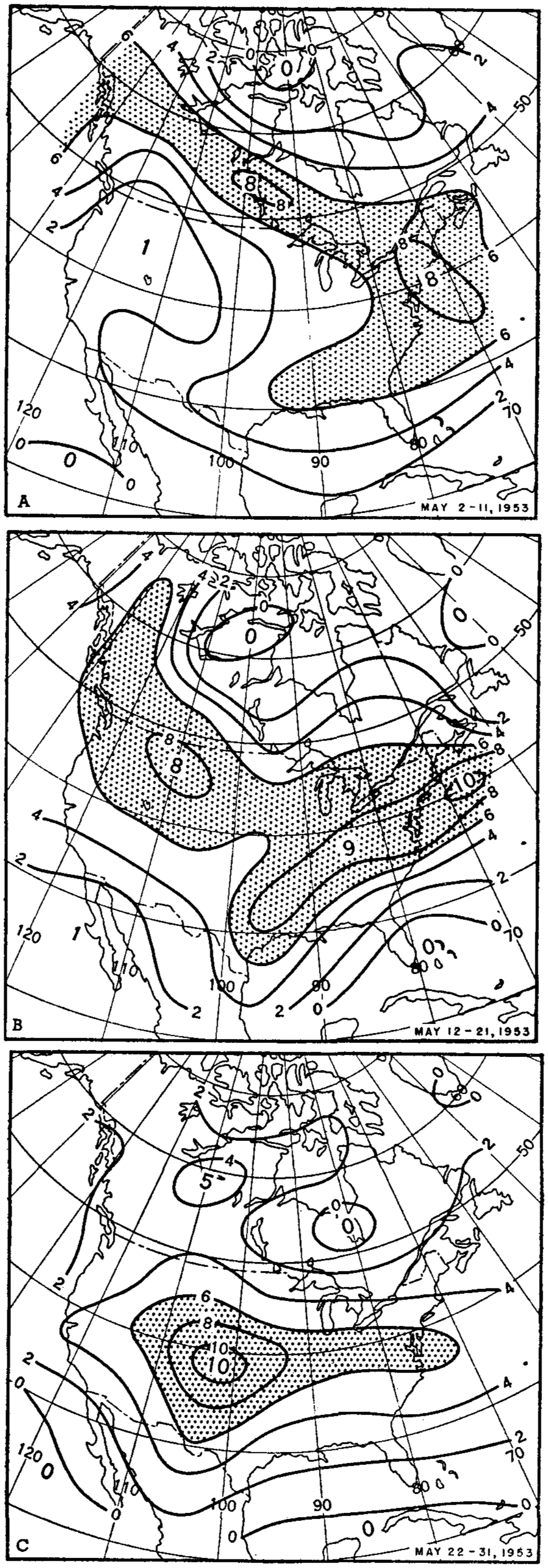


FIGURE 5.—Number of days with surface fronts (of any type) located within square areas with sides approximately 430 nautical miles in length for (A) May 2–11, 1953, (B) May 12–21, 1953, and (C) May 22–31, 1953. Frontal positions were those appearing on printed Daily Weather Maps for 1830 GMT. Areas where fronts were present on six or more days are shaded. Note great frequency of fronts over South and East in first two decades of month which was closely associated with heavy rainfall in these areas as shown in figure 4.

mean cyclonic circulation located over the North Dakota-Minnesota boundary. With such circulations moisture and precipitation are typically carried westward across the top of the Low, and it is not unusual for the greatest amounts of precipitation to be located northwest of the center, as in this case. Over most of the central and southern Plains precipitation was generally subnormal even though the trough was located over the area. As mentioned earlier many tornadoes occurred in this region during this period (fig. 1). As explained with respect to the monthly mean circulation, the dominance of dry Pacific air in this region accounts in part for both tornadic activity and subnormal rainfall. Very dry weather over most of the Rockies, the Plateau, and the California coast was associated with the ridge along the West Coast, the anticyclonic flow pattern over the West, and the almost complete lack of fronts (fig. 5A).

During the middle ten days of May the circulation pattern had changed in several respects from the first ten days (fig. 3B). One of the most fundamental changes occurred over the Pacific where one major central Pacific trough had replaced the two troughs observed earlier. Accompanying this trough amalgamation were the following changes:

(1) A ridge appeared well off the West Coast, some 15° of longitude west of the previous ridge position along the Coast.
(2) The trough in the Southwest sheared off from its connection to the northeast and built northwestward through Nevada.
(3) A ridge developed over the Southeast and a closed High formed over Florida.
(4) A weak trough developed in the western Atlantic.

Meanwhile at higher latitudes the flow over Canada broke down markedly into a blocking type with closed High centers in western and northeastern sections and a deep Low centered on the southwest side of Hudson Bay. The trough which had been over the Plains extended southward from this Low.

Most of these changes had immediate repercussions on the precipitation regime. As the southwesterly flow off the Gulf of Mexico retrograded so did the general axis of heavy precipitation (fig. 4B). It now stretched from Texas, Oklahoma, and Louisiana northeastward through the Ohio Valley and into northern New England and the Middle Atlantic States. Note how the axis of maximum frontal activity (fig. 5B) shifted to about the same position as the zone of maximum precipitation. Rainfall in excess of 400 percent of normal fell in east Texas and Louisiana in this period leading to the devastating floods mentioned earlier. Meanwhile, rainfall over most of the Southeast decreased to subnormal amounts as the ridge line aloft became more well-defined there and frontal activity decreased markedly. Over the central and northern Plateau and central Rockies precipitation picked up appreciably in connection with the intensifying trough over Nevada. Heavier-than-normal precipitation generally followed a channel which was located roughly between the zonally oriented 9,900-ft. and 10,000-ft. contours (fig. 3B), south of the axis of maximum number of days with fronts (fig. 5B), and north of the sea level cyclone centers (Chart X). All of the West Coast to the north of central California was wet due to frequent frontal systems moving in from a fast westerly current in the Pacific.

The last ten days of the month saw the changes evident during mid-May culminate in a large amplitude wave pattern over the United States (fig. 3C), which represented a nearly complete change in phase from the pattern which was dominant in the first third. From the central Pacific to eastern North America all waves at middle latitudes had retrograded while the amplitudes of the eastern Pacific ridge, the United States trough and ridge, and the western Atlantic trough all increased. Most striking development over the United States was the establishment in these last ten days of May of a continental anticyclone with center over Alabama. The influence of this huge anticyclonic circulation was remarkable in bringing a complete halt to rainfall over virtually all of the South from Texas and Oklahoma eastward to the western Carolinas (fig. 4C). East Texas, Louisiana, Mississippi, and Tennessee experienced the most extreme change in precipitation regime as rainfall dropped from values in excess of 200 percent of normal during the middle third of the month (fig. 4B) to no rain at all in the last ten days (fig. 4C). This total lack of precipitation obviously brought an end to the severe storminess that had plagued the South in the first two-thirds of the month and it can be seen in figure 1 that no tornadoes were reported in the South after the 19th.

Heavier-than-normal precipitation in the last third of May occurred along the West Coast and the northern Plateau region in association with the deep trough along the Coast. Precipitation in excess of normal also streaked eastward across the northern border region of the United States and then mainly southeastward into the Middle Atlantic States. It is noteworthy that the band of above-normal precipitation across the northern United States was generally oriented in the direction of the flow pattern of figure 3C. Strongest wind speeds at 700 mb. across the United States at this time were located between the 10,000-ft. and 10,400-ft. contours, with the maximum wind axis very close to the 10,200-ft. contour. Note that heavy precipitation fell on the north side of the maximum wind axis from the West Coast to Michigan and generally directly under the maximum winds from Lake Erie to coastal New Jersey and Delaware. It is interesting that the axis of maximum frontal activity in these last ten days (fig. 5C) did not coincide with the axis of heaviest precipitation as it did in the earlier two decades of the month. As an extreme example, fronts were found in eastern Colorado and western Kansas on every one of the last ten days of May, yet precipitation was largely subnormal. The most likely explanation for this lack of precipitation where fronts were most frequent lies in the prevailing upper-level anticyclonic circulation over these fronts which suppressed the upward motion necessary for rainfall, and which also prevented much flow of tropical air over the fronts in mid-troposphere.

TEMPERATURE IN RELATION TO MEAN CIRCULATION

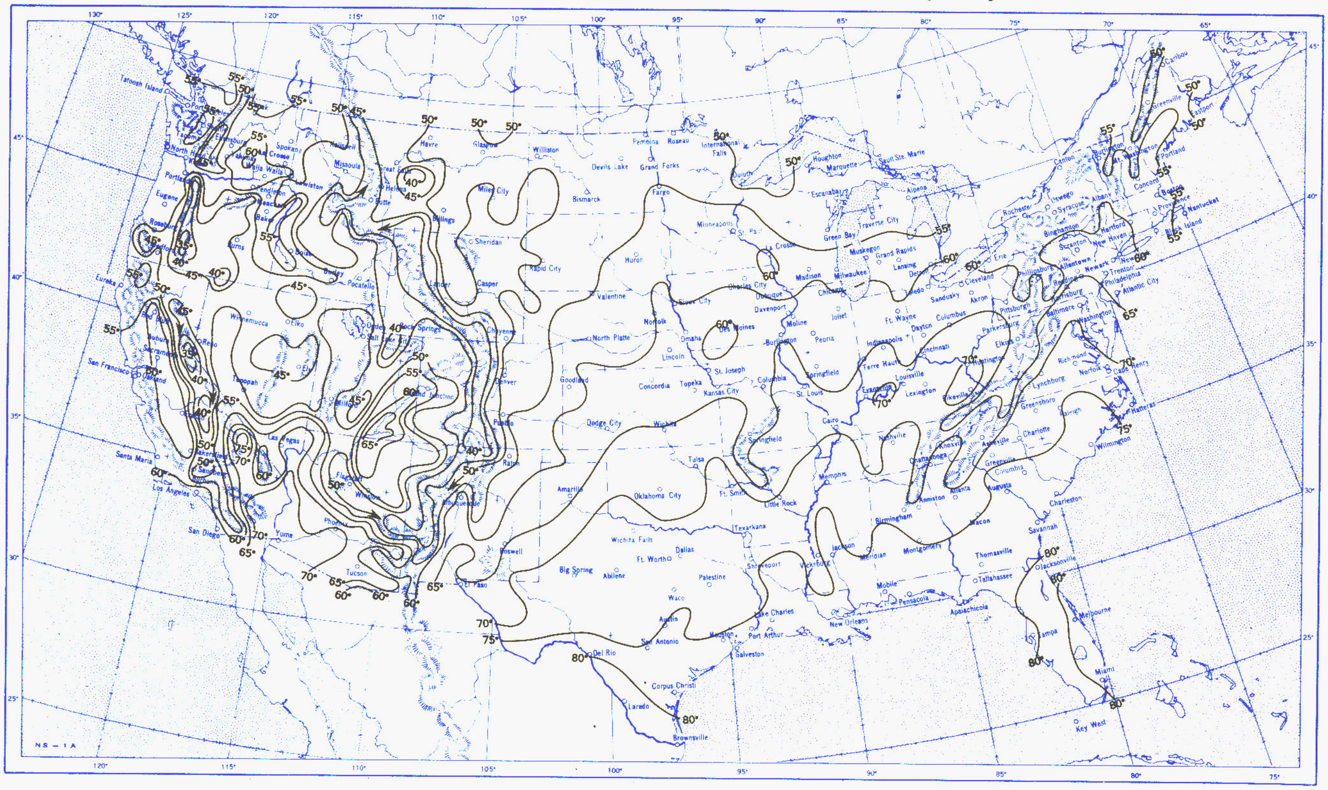
This month's mean temperature anomalies (Chart I–B) were well related to the monthly mean 700-mb. circulation pattern (fig. 2). Temperatures averaged below normal over the western half of the Nation, where the major mean troughs were located and where 700-mb. heights were below normal. The coldest weather (6°–9° F. below normal) occurred over the Great Basin, directly under the negative height anomaly center at 700 mb. The air masses contributing to most of these subnormal temperatures were predominantly polar Pacific, coming into the West under the influence of the prevailing cyclonic circulation which prevented rapid low-level warming of the air mass over the continent. Over the eastern half of the country May was a rather warm and often humid month. This warmth was associated with southerly flow relative to normal over the Mississippi and Ohio Valleys and positive 700-mb. height anomalies in the ridge over the East. Moist maritime tropical and considerably modified polar air were dominant over this part of the country.

Near the boundary between above and below normal monthly mean temperatures there are often marked swings in temperature during short periods within the month. This was especially true this month in the region from the Southern Plains northeastward toward the Great Lakes, where temperatures averaged rather close to normal for the month as a whole (Chart I–B). A striking example of this situation occurred in Oklahoma and northwest Texas where, during the week ending May 18, temperatures averaged 12° to 13° F. below normal when a strong outbreak of cold Canadian air moved southward through the Plains. A week later in the same area temperatures averaged more than 9° to 11° F. above normal as the warm anticyclone developed over the area aloft. Record maximum-temperatures for so early in the season occurred at several stations. Among them was Amarillo, Texas, where 102° F. was reported on the 25th.

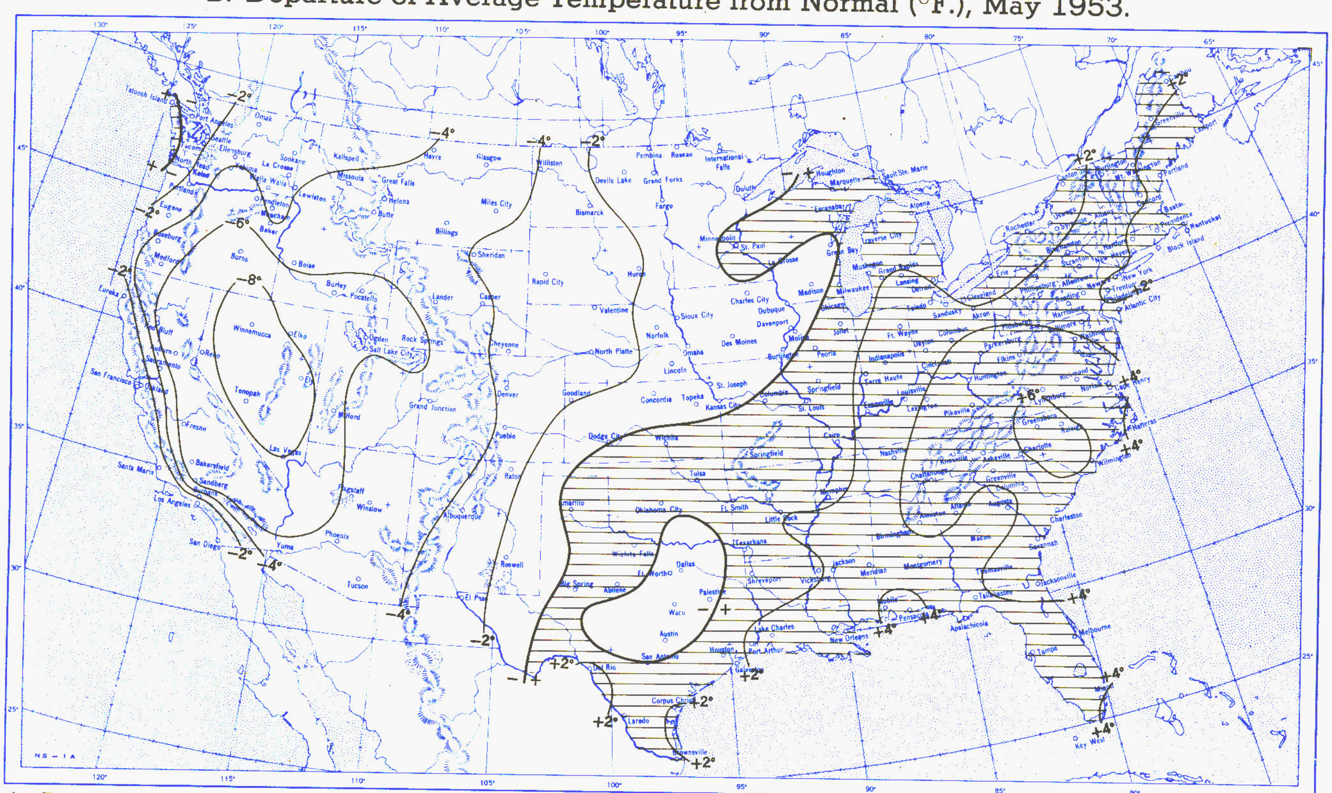
REFERENCES

1. U. S. Weather Bureau, "Tornado Occurrences in the United States," Weather Bureau *Technical Paper* No. 20, Washington, D. C., September 1952, 43 pp.
2. J. R. Fulks, "The Instability Line," *Compendium of Meteorology*, American Meteorological Society, 1951, pp. 647–652.
3. W. H. Klein, "The Weather and Circulation of April 1953—A Cold, Stormy Month with a Low Index Circulation," *Monthly Weather Review*, vol. 81, No. 4, April 1953, pp. 115–120.

Chart I. A. Average Temperature (°F.) at Surface, May 1953.



B. Departure of Average Temperature from Normal (°F.), May 1953.

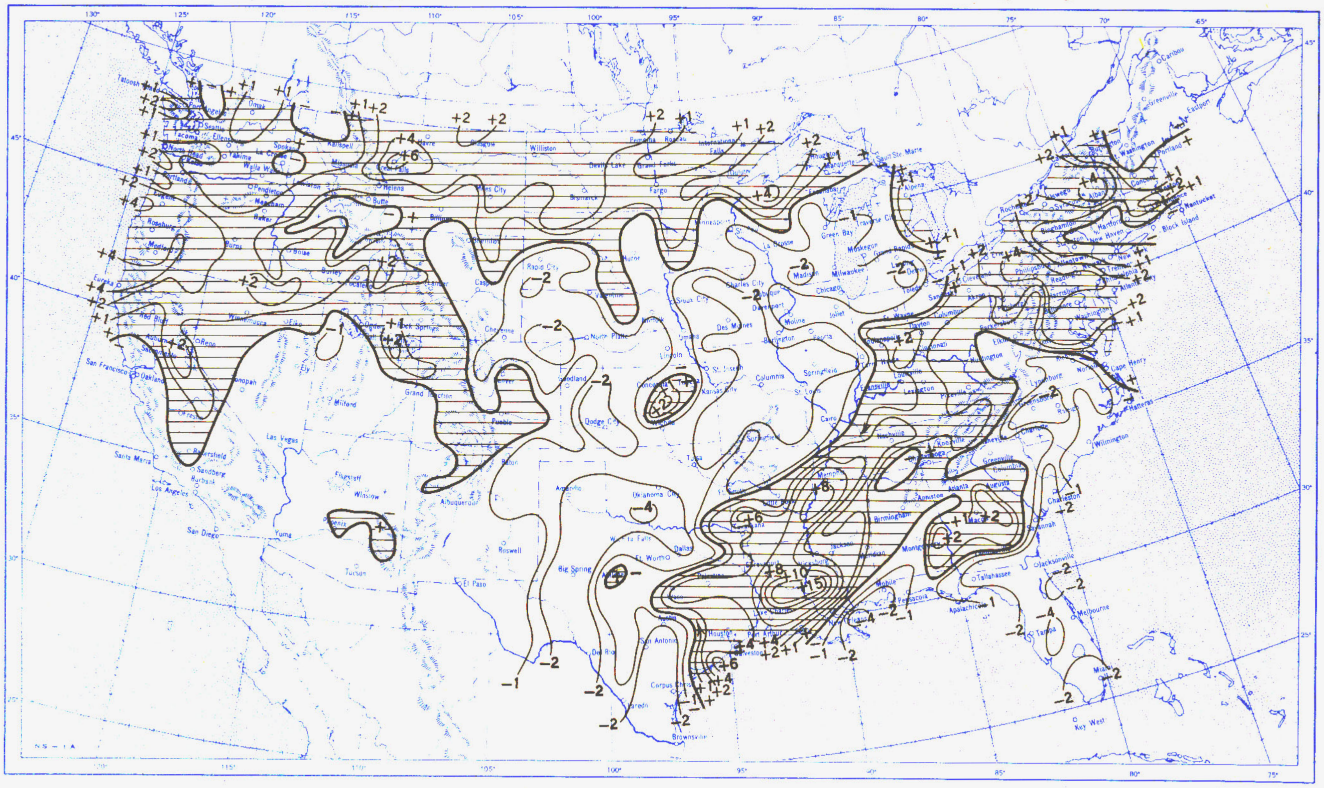


A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

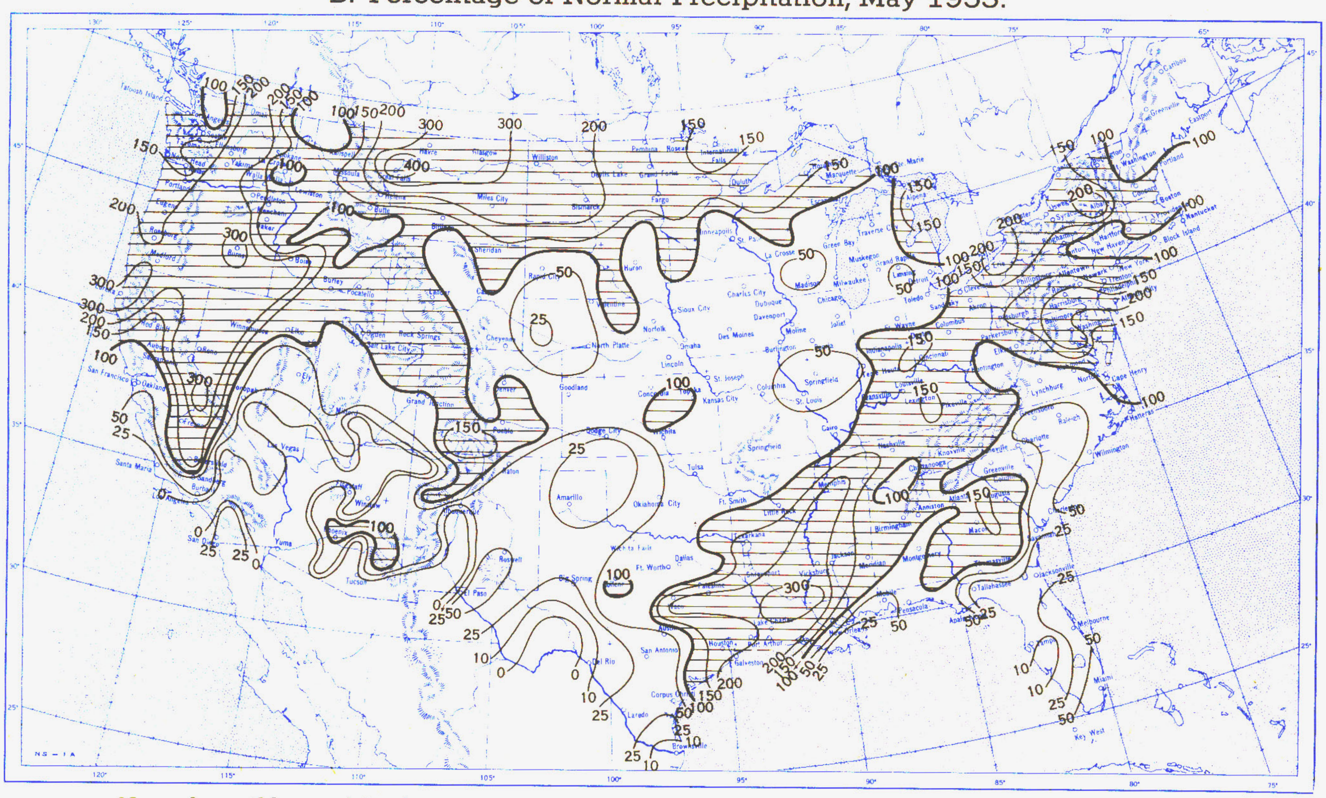
Chart II. Total Precipitation (Inches), May 1953.

Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), May 1953.

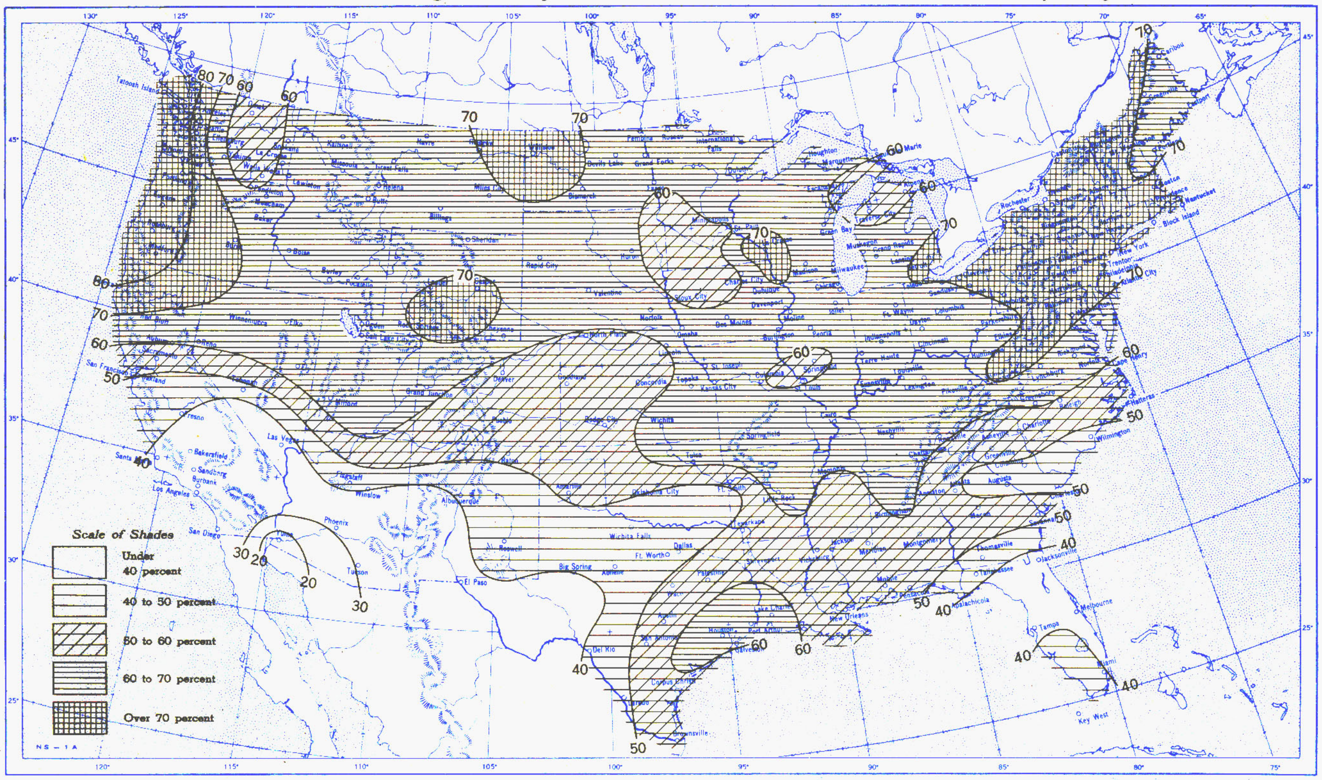


B. Percentage of Normal Precipitation, May 1953.

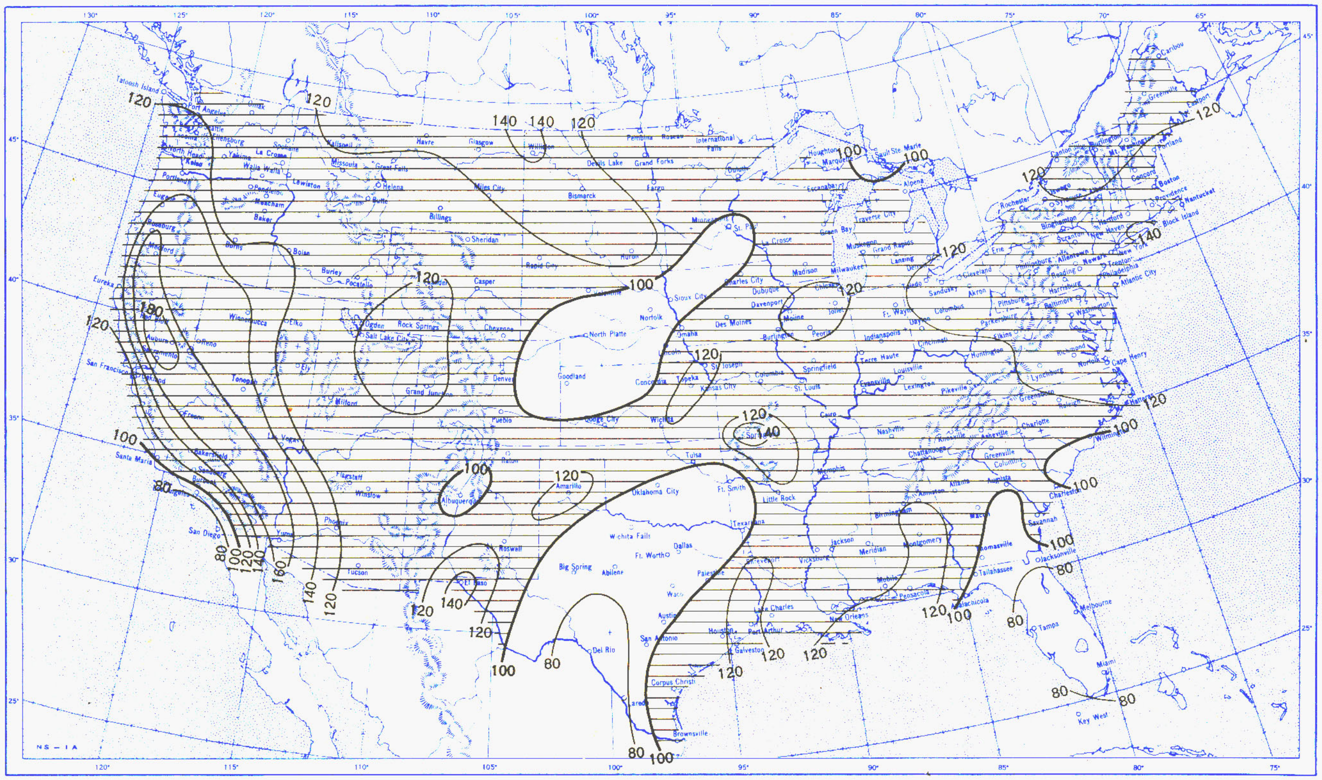


Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, May 1953.

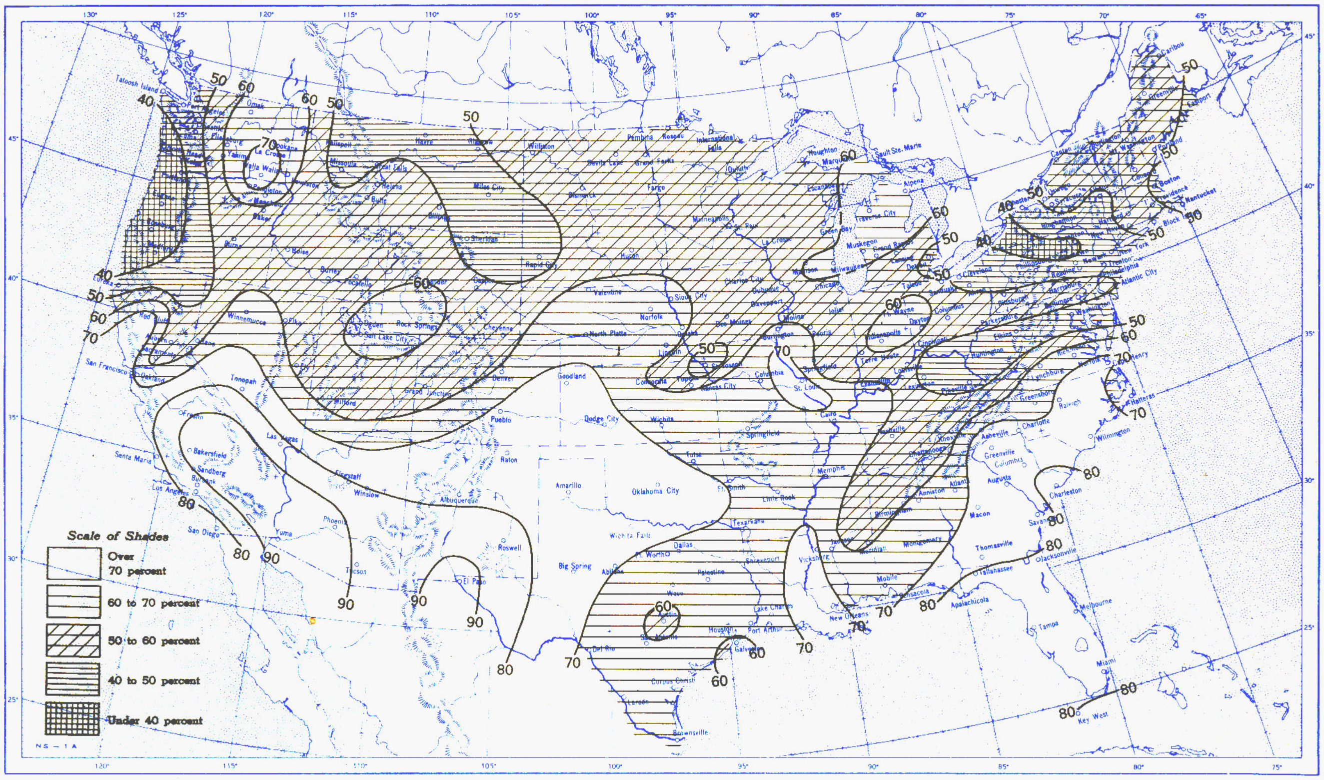


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, May 1953.

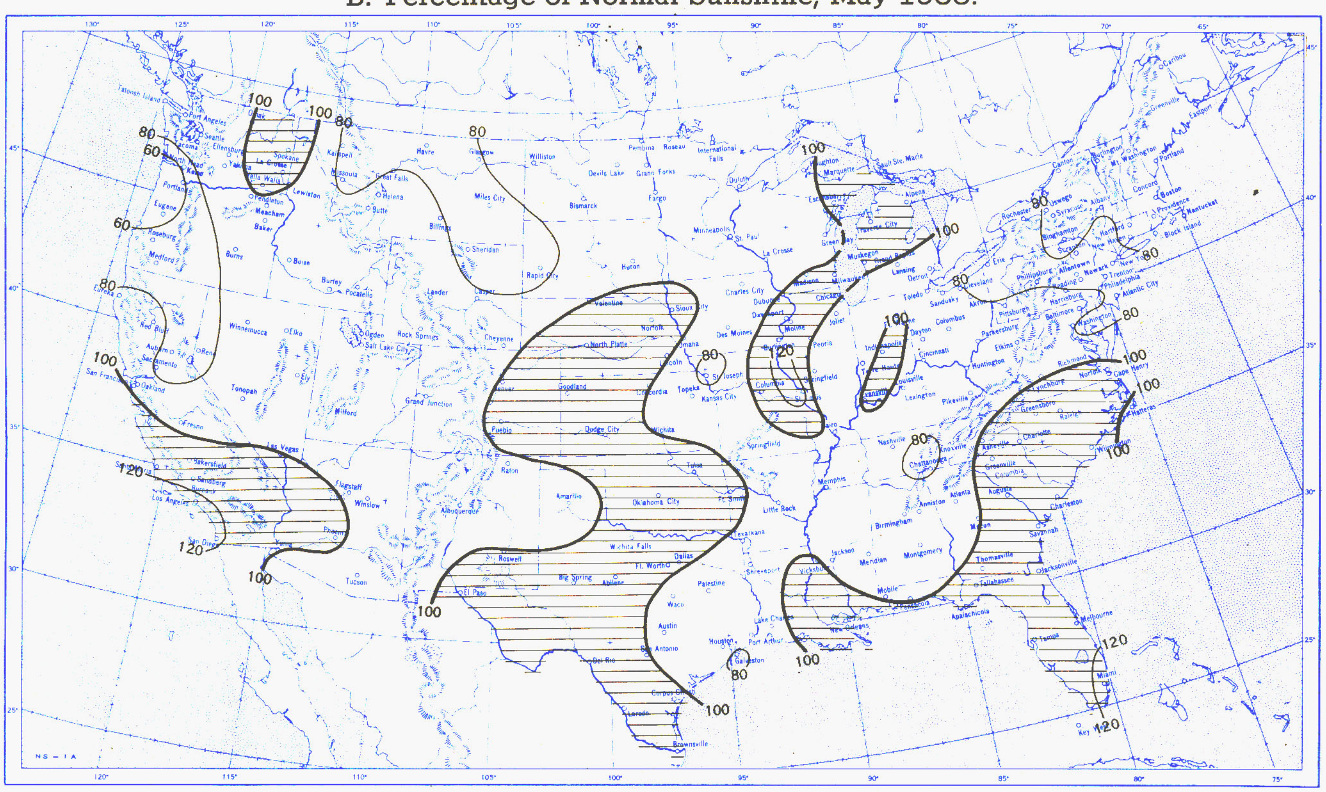


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, May 1953.



B. Percentage of Normal Sunshine, May 1953.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, May 1953. Inset: Percentage of Normal Average Daily Solar Radiation, May 1953.

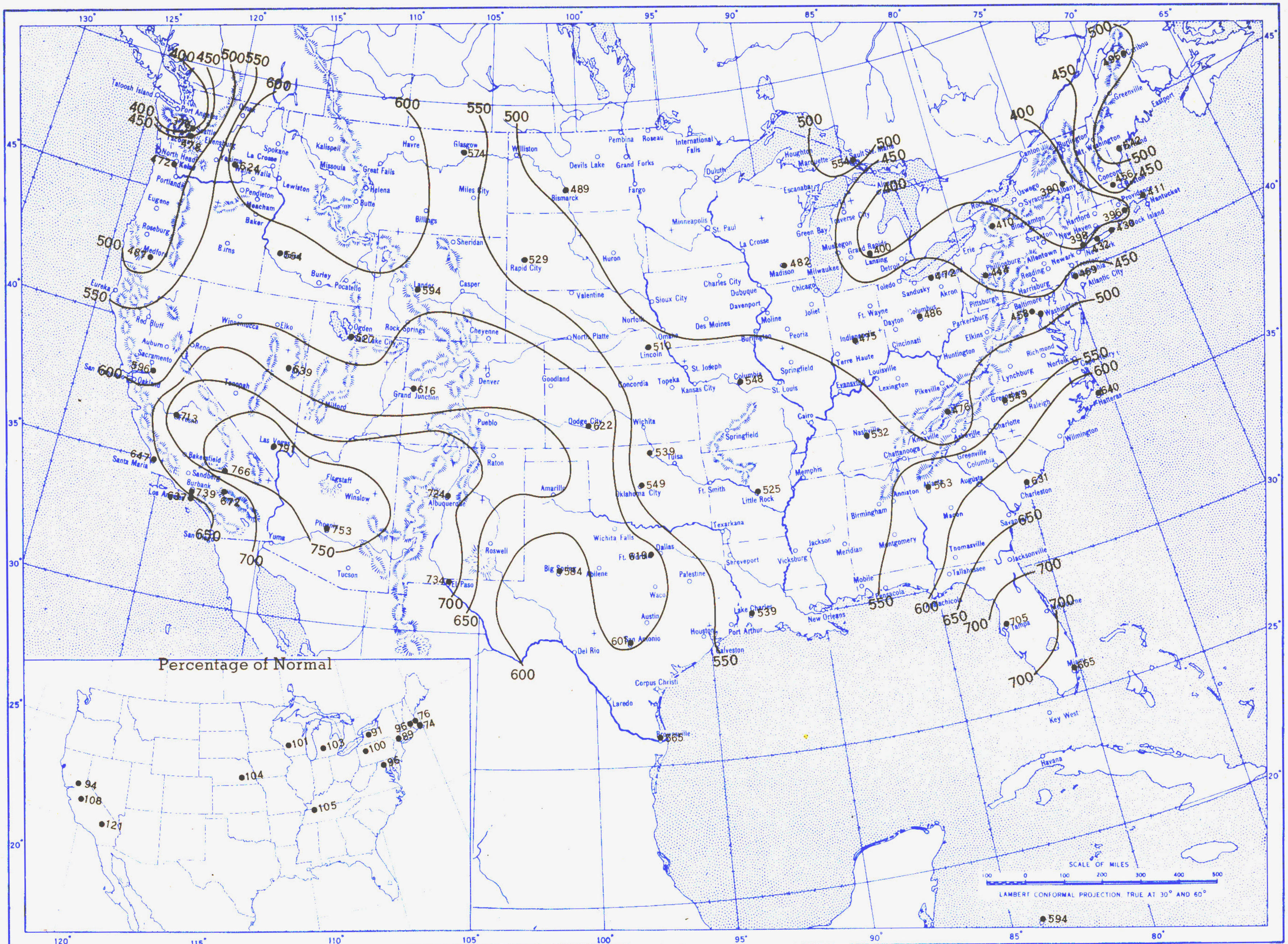
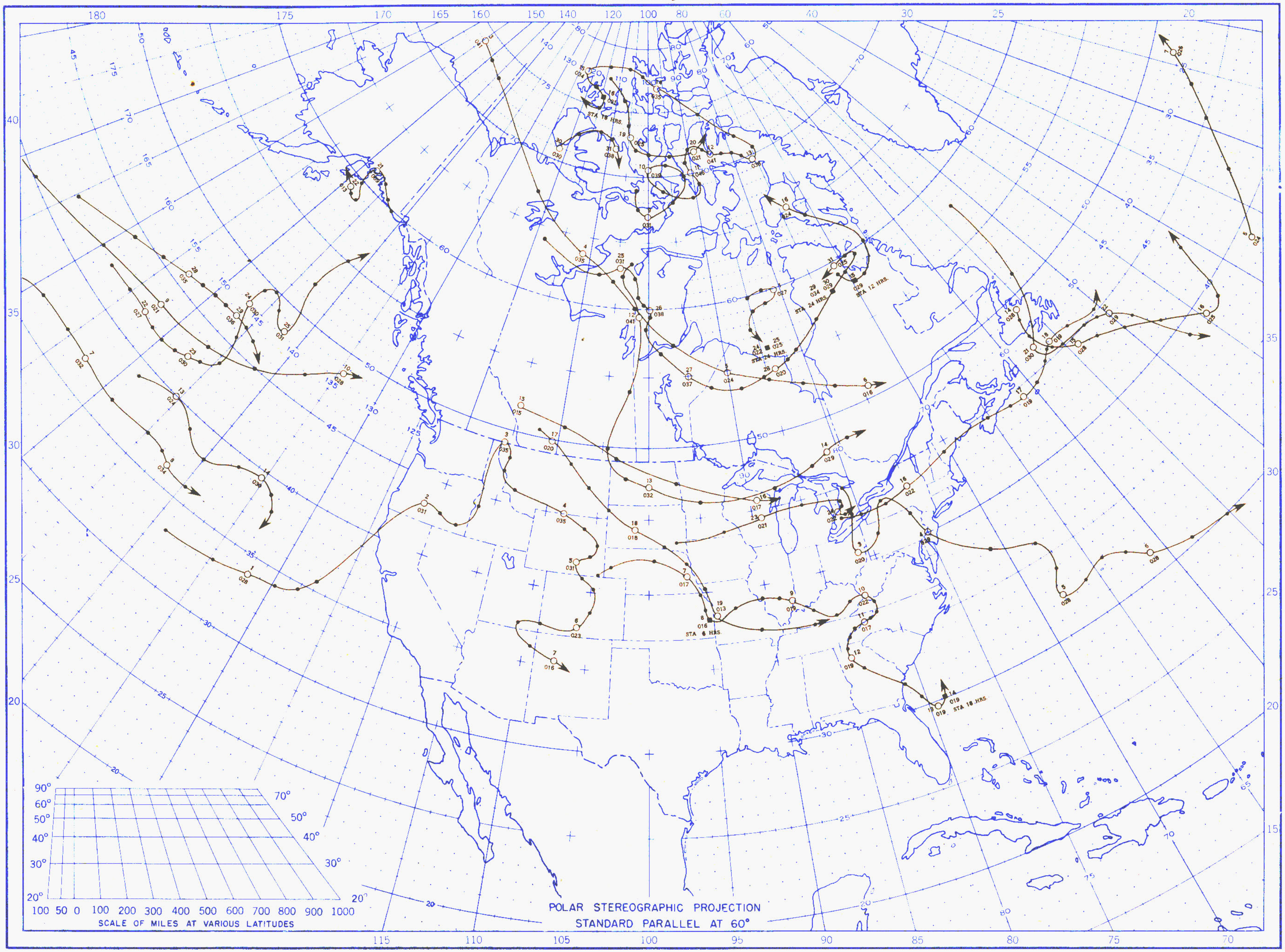


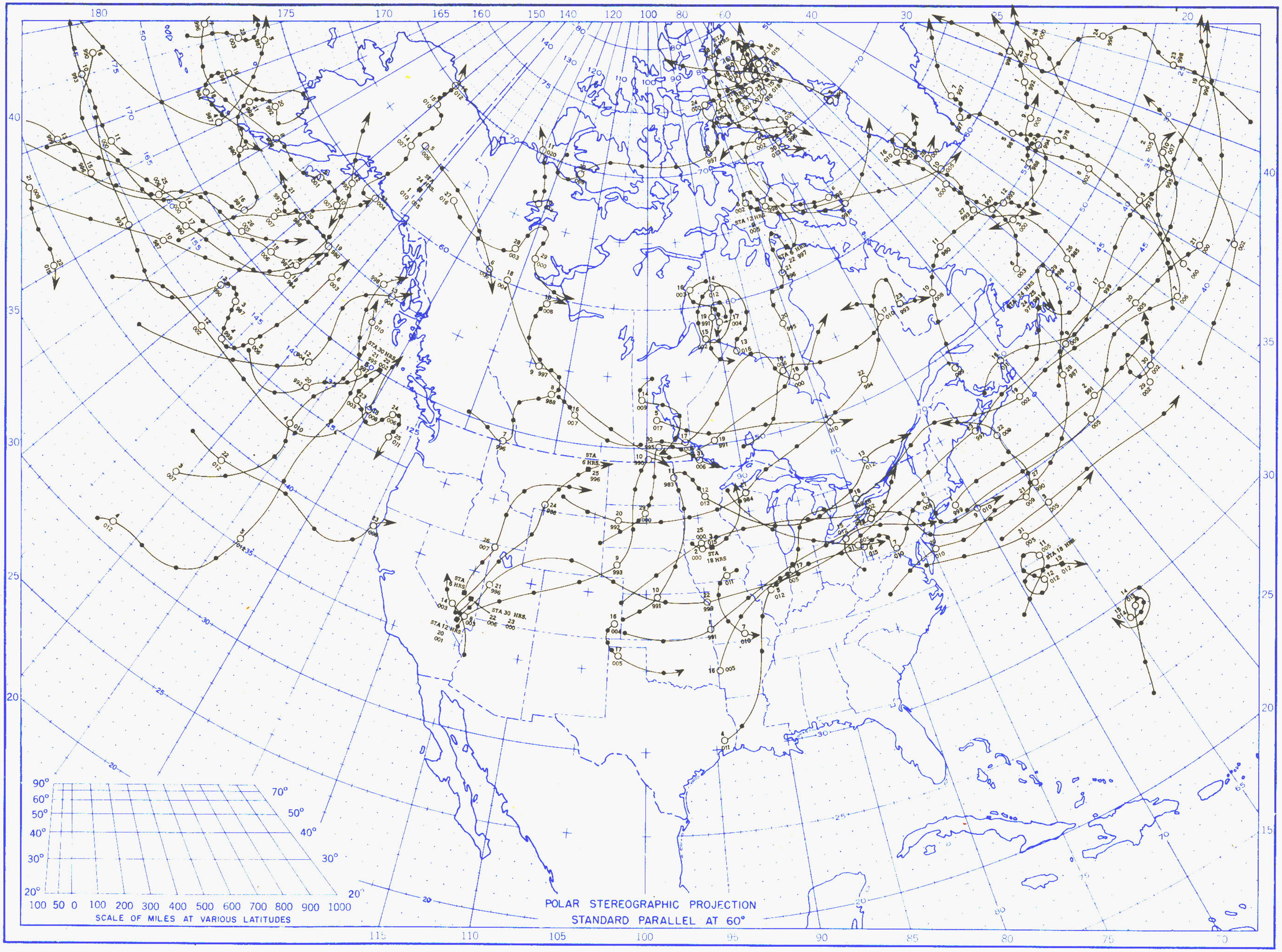
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. Normals are computed for stations having at least 9 years of record.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, May 1953.



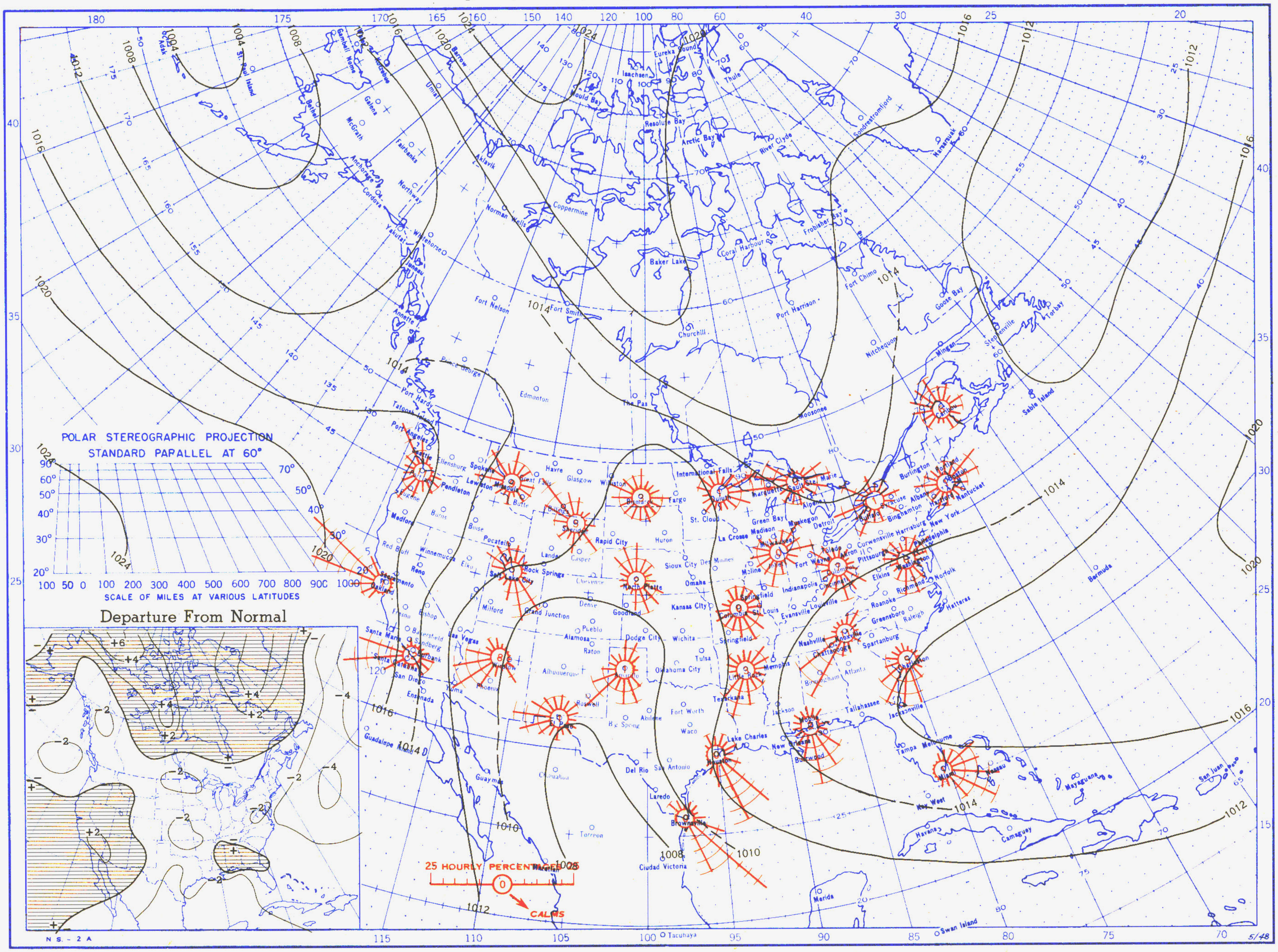
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, May 1953.



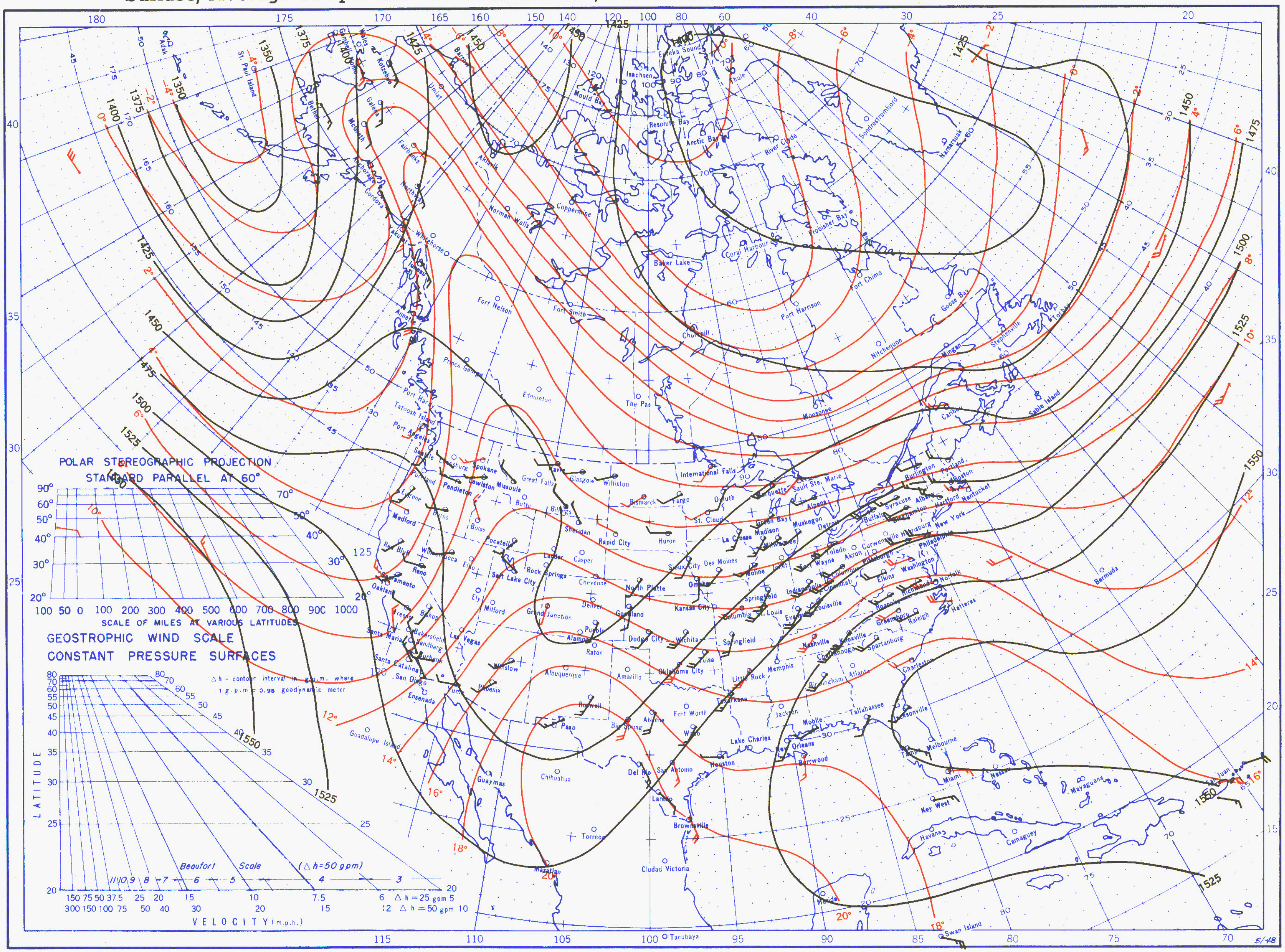
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, May 1953. Inset: Departure of Average Pressure (mb.) from Normal, May 1953.



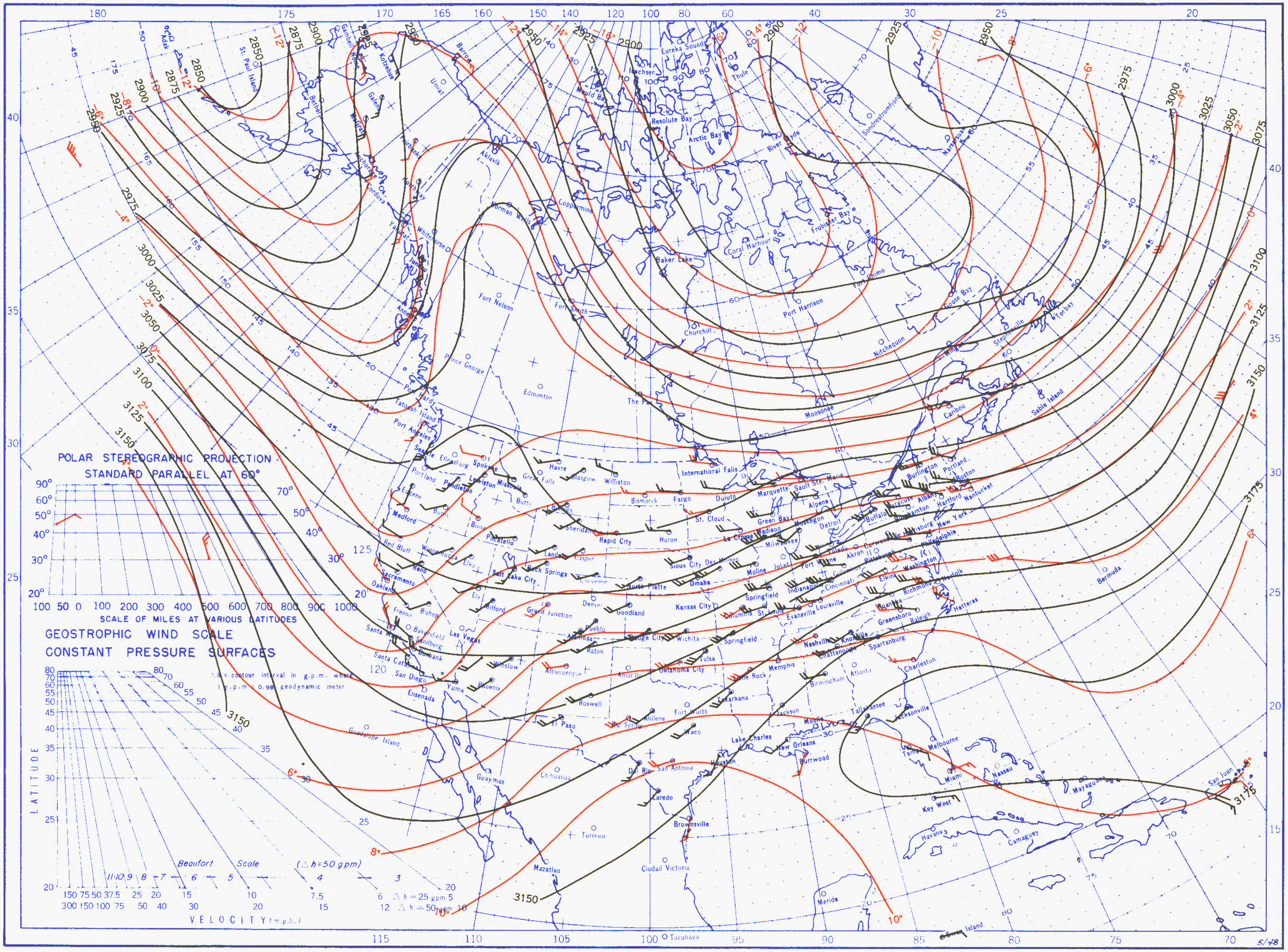
Average sea level pressures are obtained from the averages of the 7:30 a.m. and 7:30 p.m. E.S.T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), May 1953.



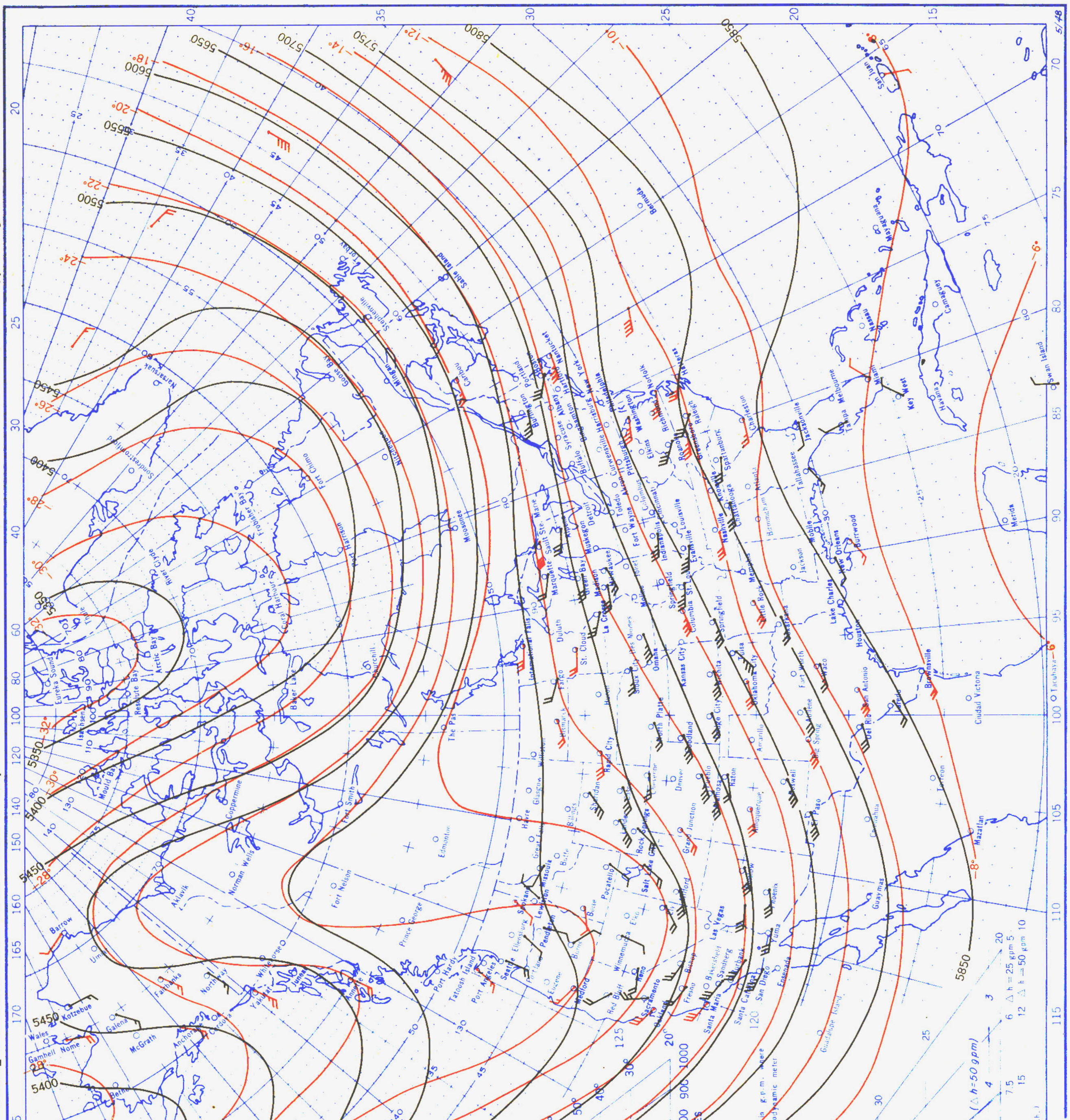
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m.. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), May 1953.



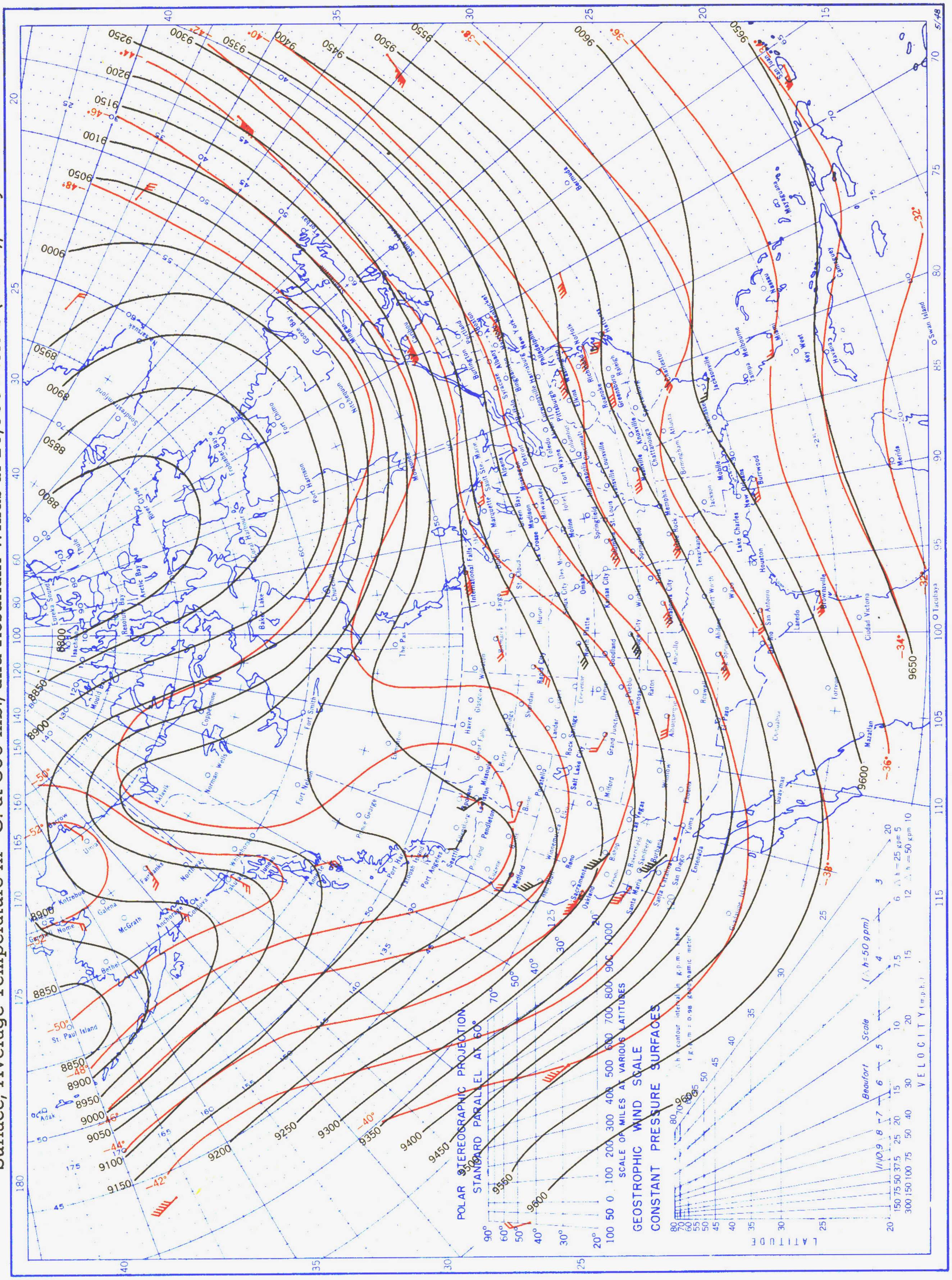
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.

Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), May 1953.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), May 1953.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T.